BLM LIBRARY
88018463

BLM-AK-PT-89-036-6700-040

Bird Communities of Recently Burned and Unburned Forest and Scrub Habitats in Interior Alaska

Michael T. Hinkes
and
Kate Engels

Open File Report 25

BUREAU OF LAND MANAGEMENT

ALASKA

June 1989

JK
870
.L3
O6
no.25

Open File Reports

The category of "Open File Report" is used by BLM-Alaska to identify the results of inventories or other investigations that are made available to the public outside the formal BLM-Alaska technical publication series. These reports include preliminary or incomplete data that are not published and distributed in quantity but that are available for public inspection at BLM offices in Alaska, the USDI Resources Library in Anchorage, and the various libraries of the University of Alaska.

Copies of open file reports are also available for inspection at the USDI Natural Resources Library in Washington, D.C. and at the BLM Service Center Library in Denver.

20046718
ID 88018463

BLM LIBRARY
SC-324A, BLDG. 50
DENVER FEDERAL CENTER
P. O. BOX 25047
DENVER, CO 80225-0047

JK
870
.L3
06
no.25

Table of Contents

Page

List of Figures

List of Tables

MANAGEMENT HIGHLIGHTS

Composition and density of bird communities on recently burned (3 and 8 years old) and unburned sites in 5 plant communities were studied in interior Alaska during the breeding seasons of 1979 and 1980. Plant communities examined included closed mixed forest, open needleleaf forest, closed low shrub scrub, open low shrub scrub and open dwarf shrub scrub. Differences between bird communities on recently burned and those on unburned sites were dramatic, the degree depended on the plant community being examined.

Total avian densities in all 5 plant communities were highest on unburned sites. Densities in open needleleaf forest and low shrub scrub communities were more than twice the density in the burned sites. Species richness and diversity were also highest on unburned sites, except for the dwarf shrub scrub community, where species richness and diversity were greatest on the most recently burned site. Standing crop biomass, consuming biomass and existence energy estimates followed a similar trend. In forested and low shrub scrub communities, all 3 estimates of bioenergetics were higher in the unburned sites than in the recently burned sites, except in dwarf shrub scrub, where estimates were highest on the most recently burned site.

Measures of overlap showed that similarity was least between avifaunal populations on recently burned sites as compared with unburned sites for forest communities in general and for closed low shrub scrub containing islands of forest-type vegetation. The greatest overlap between the burned and unburned sites occurred in both open low shrub scrub and dwarf shrub scrub communities and overall, showed a high degree of similarity between all sites in the open low shrub scrub and dwarf shrub scrub communities.

Bird species composition varied between recently burned and unburned sites. Birds that foraged in trees and tall shrub foliage were much less abundant on the recently burned sites. Tree foliage searchers such as the boreal chickadee, pine grosbeak, Ruby-crowned kinglet, white-winged crossbill and blackpoll warbler were observed almost entirely on unburned sites. Availability of tree and tall shrub foliage was significantly less on burned sites, resulting in lower numbers of these bird species.

The effect fire had on ground-bush forages varied depending on the habitat occupied and the species of bird considered. Total density of this guild was highest on the burned sites of forest communities. The density of ground-bush foragers such as tree, white-crowned, chipping and Lincoln's sparrows was much higher on recently burned sites. Fire within the forested community resulted in an "open" habitat which these species prefer. However, some ground-bush foragers such as the Swainson's thrush, varied thrush, and spruce grouse were found almost exclusively on unburned sites.

Non-forested communities, both burned and unburned, were dominated by ground-bush forages. Some species that were abundant on recently burned sites in forested habitats, were less abundant on burned sites in non-forested communities. Although fire created open habitat in forested communities, allowing ground-bush foragers to increase, fire reduced the total amount of vegetation available for feeding and cover in non-forested communities, therefore reducing the number of birds which could be supported.

Dominance values illustrated that individual birds were concentrated in fewer species on recently burned sites in forested and low shrub scrub communities compared to the more species-rich unburned sites. However, in the dwarf shrub scrub community, the reverse was true. Strongly dominant bird communities have sometimes been related to the "harshness" of the environment. If so, our results indicate that recently burned forest and low shrub scrub sites are harsher than the unburned habitat.

Species richness and diversity was highly correlated with vertical structure diversity ($P < 0.01$), a measure of habitat structure. The greater number of vegetation layers on unburned sites provided for a greater number of species through both the addition to and the expansion of the foraging guilds. This was particularly true in forested and closed low shrub scrub communities, where the habitat structure in unburned sites provided more nesting sites and foraging substrates. However, in less diverse communities, where vegetation on both the burned and unburned sites was limited to a single layer, differences in species richness and composition were less dramatic.

Our results indicate that fire, whether naturally occurring or manually ignited, results in habitat alterations and subsequent changes in breeding bird communities. The degree of change depends largely on the pre-burn vegetation and the species of bird affected. Fire in more structurally complex habitats, such as forested communities, results in the greater overall change in bird community composition and abundance than fire in more structurally simple habitats, i.e. scrubland. However, the presence of structural features such as standing water and unburned island of vegetation will reduce the magnitude of change in bird communities following fire.

INTRODUCTION

Ecological succession is an orderly process of community development involving changes in plant and community processes with time, and results from modification of the physical environment (Odum 1971). In Alaska, wildfire is a major factor in the modification of the northern environment. Lightning and man-caused wildfire have burned an average of 600,000 to 1,00,000 ha annually (Barney 1971). The Alaska Taiga of the Interior consists of a vegetation mosaic resulting largely from fire (Viereck 1973).

Composition and structure of plant communities dictates food quantity and quality, nest site availability and cover, thus influencing bird species diversity and abundance in the community. Alteration of plant communities as a result of wildfire causes changes in bird communities. Studies by Marshall (1963), Lawrence (1966), Emlen (1969), Boch and Lynch (1970), Bendell (1974), Lowe et al. (1978), Niemi (1978), Quinlan (1979) and Taylor and Barmore (1980) all reveal significant changes in avifauna following fire. Clearcutting also causes vegetation alterations resulting in bird community changes (Kessler 1979, Franzreb and Ohmart 1978, Nobel 1977, Conner and Adkissen 1975, Kilgore 1971 and Hagar 1960).

In Alaska, little quantitative information has been collected on bird community changes following fire. Quinlin (1979), working on the Kenai Peninsula, compared bird communities in five stages of plant succession in white spruce forest. Ellison (1975), also working on the Kenai Peninsula, compared spruce grouse populations before and after fire. Although these studies provide valuable data, little information is available on the effects of fire on bird communities for interior Alaska, nor for non-forested communities.

Land management agencies in Alaska are deferring from a policy of fire suppression to one utilizing fire to accomplish resource management objectives (Viereck and Schandelmeier 1980). A major objective is to improve moose winter range by means of prescribed fire. Quantitative information on the effects of fire on vegetation and associated bird populations is needed to evaluate and mitigate the effects of fire management activities on avian resources.

The purpose of our investigation was to compare bird species composition, density and diversity in unburned and recently burned sites within forest and low shrub scrub and dwarf shrub scrub cover types.

DESCRIPTION OF STUDY AREA

The study was conducted on the 1977 Bear Creek Burn (140,000 ha) and the 1972 Farewell Burn (13,500 ha) located approximately 240 km northwest of Anchorage and 40 km southeast of McGrath, Alaska (Fig. 1). The Bear Creek study area was located between the western slopes of the Alaska Range and the South, Windy and Middle Forks of the Kuskokwim River, and at latitude 62°40' North and longitude 154°00' West. The fires burned a variety of plant communities including needleleaf and deciduous forest, low and dwarf shrub scrub, sedge-tussock tundra. Forest communities included extensive black spruce (*Picea marian*) stands, white spruce (*P. glauca*) and mixed needleleaf-broadleaf stands.

The study area is within the Tanana-Kuskokwim lowlands of the Alaskan Intermontane Plateau Physiographic Region (Wahraftig 1965). Topography is level except for 3 undulating ablation moraines. Elevation ranged from 480 m at the base of the Alaska Range to 90 m at the Kuskokwim River.

The climate is typical of interior Alaska with long, cold winters and short, cool summers. Winter temperatures range between -50°C and 2°C, whereas summer temperatures average 13°C. Mean daily temperature during the study was 11.2°C with occasional sub-freezing temperatures in the evenings. Annual precipitation for the Bear Creek area averages 42.4 cm. Mean monthly precipitation during the summer months (June through August) is 6.1 cm, with most occurring in the form of rain. Winds are generally 6.8 m/sec to 18.0 m/sec and were a major environmental factor affecting the area. A calm day was a rarity.

METHODS

Site Selection

Five vegetation cover types were selected for comparing bird communities on unburned (control) and recently burned sites. The recently burned sites included the 3-year-old Bear Creek fire, which occurred in 1977, and the 8-year-old Farewell Fire, which occurred in 1972. Unburned sites were selected to represent the preburn vegetation of each plant community. Interpretation of burned vegetative remains, unburned islands, and pre-burn aerial photography and satellite imagery were used to determine pre-burn vegetation before unburned control sites were selected. Unburned and burned sites sampled included:

Cover Type	Condition	Sites	Size
Closed Mixed Forest	Unburned	1	54.7
	3-year-old	2	52.4
Open Needleleaf Forest	Unburned	2	60.1
	8-year-old	2	57.8
Closed Low Shrub Scrub	Unburned	1	20.4
	3-year-old	1	34.3
Open Low Shrub Scrub	Unburned	1	46.1
	8-year-old	2	76.3
	3-year-old	1	32.5
Open Dwarf Shrub Scrub	Unburned	1	29.0
	8-year-old	1	46.6
	3-year-old	1	32.9

Vegetation was classified to Level III of the 1982 Revision of Classification system for Alaskan Vegetation (Viereck and

Dyrness, 1982). All sites contain a minimum of 30 ha of homogeneous vegetation.

Vegetation Analysis

One permanent quarter-hectare plot was established in each unburned and each burned sample site. Estimates of burn severity, scorch height, standing tree density (alive and dead), fallen tree density (burned and unburned), depth of burn, depth of permafrost (active layer), and other notes on physiography were made in each plot. Canopy cover was estimated by aerial photo interpretation.

Sixteen subplots measuring .5 m x 2.0 m were systematically located and permanently marked within each quarter-hectare plot. Percent cover for each shrub, forb, lichen, moss, and for nonliving material was estimated according to cover classes described by Daubenmire (1959).

Vertical structure distribution was estimated with a toe-point transect established within each sample site. Each transect was divided into 200 equally spaced recording points. At each recording point, recognized by a mark on the pacer's boot, an imaginary transect of infinite length was imagined to extend vertically. Any plant canopy crossing the transect was recorded in its appropriate height class. Height classes include: Basal, the plant or substrate at ground level; Class 1, less than .3 m; Class 2, .3 m to .6 m; Class 3, .6 m to 1.2 m; Class 4, 1.2 to 4.5 m; and Class 5, greater than 4.5 m. Foliage height distribution values were calculated by summing the total number of plants recorded in each height class.

An index of foliage volume to 3.6 m was estimated, using a version of the vegetation profile board described by Nudds (1977). The vegetation profile board was 1.8 m high by .3 m wide divided into 6 alternating black and white .3 m x .3 m squares painted along the length of the board. The reader stood 12 m from the board, which was placed vertically on end and estimated the percentage of foliage in each square. After these 6 readings were made, the board was lifted 1.8 m off the ground and 6 additional readings were made up to the 3.6 m level. This procedure was followed at each of the cardinal directions oriented from the center of the quarter-hectare plot.

Avian Composition and Density

Avian communities were sampled during the breeding seasons of 1979 and 1980 (last week in May through the first week in July). Sample sites within open needleleaf forest, closed low shrub scrub and open low shrub scrub plant communities were measured both years. Those in the closed mixed forest community were measured during 1979, while open dwarf shrub scrub sites were measured during 1980.

Bird community composition and density were estimated using a belt transect 240 m in width. Transect length ranged from 835 m to 2,240 m, with a mean of 1,514 m. An effort was made to keep transect lengths equal between unburned and burned sites compared to insure that differences in avian composition and density was due to vegetation structure and not the size of sample area (MacArthur and MacArthur 1961). The observer walked along the centerline of the belt transect identifying birds by visual or aural cues as singing or non-singing individuals and recorded them with distance categories of 7.5 m, 15 m, 30 m, 60 m and 120 m either side of the transect line. Transects were censused at least 3 times during the breeding season, beginning at approximately 3:00 a.m. and continuing for a maximum of four hours.

Density estimates for most passerines were based on the number of singing males with 30 m either side of centerline (representing a 60 m belt) and converted to breeding birds per 40 ha. Densities for flocking species and non-passerines, were based on total counts. For the purposes of our work, we assumed that all singing males could be detected within this distance regardless of the denseness of vegetation. The 60 m belt used fell within the range of a belt transect found acceptable by Breckenridge (1935), Haapanen (1965) and Emlen (1977). Birds located outside the 60 m belt but within the 240 m were listed simply as present.

Singing activities vary with the stage of the breeding cycle (Enemar 1959, Weeden 1965) and weather conditions (Carbyn 1971). Because of logistical problems (many sites were helicopter access only) and the often less than prime weather conditions in Alaska, transects were not always censused during peak breeding periods or under ideal conditions. Density estimates based on means of these counts would have greatly underestimated actual bird densities. Palmgren (1930) and Haapanen (1965) discussed average versus maximum count density values and noted that the maximum count for species in a series of traverses approaches the actual population level more precisely than the average. Therefore, a maximum count procedure rather than a mean count was used in calculating density values.

RESULTS AND DISCUSSION

Although unburned sites were selected to represent the pre-burn vegetation of the recently burned sites, conceivably there may have been some subtle differences between those sites prior to the fire. Therefore, our results should be treated as a comparison between unburned and burned sites and not a before and after study. Also, because our study dealt only with recently burned sites (3 and 8 years old), care should be taken when attempting to draw conclusions in terms of community succession.

Vegetation Analysis

Vegetation cover and structure for 5 plant communities was lower on recently burned sites than on unburned control sites (Table 1). However, some components of the vegetation rated higher on burned sites. A description of each plant community (burned and unburned) follows.

Closed Mixed Forest. Sample sites in the closed mixed forest community included an unburned site (mean stand age of 121 years and a maximum of 178 years) and a 3-year-old stand, the result of the 1977 fire. White spruce (Picea glauca) and paper birch (Betula papyrifera) were the dominant tree species on the unburned site, with a 65-75% canopy cover. Spruce averaged 18.0 m in height while birch averaged 15 m. Burn severity on the site was estimated as high, killing all trees, many of which were blown over following the fire.

Sitka Alder (Alnus sinuata) formed a tall shrub layer on the unburned site, with an average height of 4 m. Alder was also abundant along stream banks. Alder was non-existent on the burned site except for a few unburned islands which survived along the stream bank. Understory species on the unburned site were dominated by horsetail (Equisetum pratense) along with dogwood (Cornus canadensis) and rose (Rosa acicularis) compared with fireweed (Epilobium angustifolium) on the burned site which had reestablished quickly following the fire. The cryptogam layer on the unburned site consisted primarily of feathermoss (Haplomitrium sp.), and species of fern, while Marchantia polymorpha and ground moss dominated the burned site.

Open Needleleaf Forest. The sample sites in open spruce forest consisted of 2 unburned sites (mean stand age of 103 years and a maximum of 154 years) and two 8-year-old stands, the results of the 1972 burn. White spruce was the dominant tree with black spruce and balsam poplar (Populus balsamifera) present in much smaller numbers. Trees on the burned sites were dead, however, most remained standing. Very few spruce seedlings were present on the burned sites, but balsam poplar sprouts were present.

Feltleaf willow (Salix alaxenis), with an average height of 3.5 m, formed a tall shrub layer on the unburned sites. This species was resprouting on the burned sites, but plants were less than 2 m in height.

Understory vegetation on the unburned site consisted of low and dwarf shrub species including willow (Salix sp.), dwarf birch (Betula nana), cranberry (Vaccinium vitis-idaea), Artostaphyllos, rubra, bog blueberry (Vaccinium uliginosum), bearberry (Arctostaphyllos alpina), and Labrador tea (Ledum decumbens). These same species also occurred on the burned site; however, total shrub cover was 25% less. Herbaceous cover was twice as great on the burned site as a result of the fire. Lichens and feathermoss which dominated the cryptogam layer on the unburned site were almost non-existent on the burn, consisting primarily of litter and ground moss (Grimea sp.).

Closed Low Shrub Scrub. The closed low shrub scrub community differed from the open low shrub scrub in having denser shrub canopy cover and islands of dense white spruce and balsam poplar stands. White spruce stands were found on the upper portion of south and west-facing slopes. Individual spruce and aspen trees were also scattered throughout the area in small numbers.

Most abundant shrubs included: resin birch (Betula glandulosa), dwarf birch, willow and blueberry. Herbaceous species comprised a small percentage (12.3%) of the total cover with major species including: Balium sp., Lupinus arcticus, and dogwood. The cryptogam layer consisted of feathermoss, Peltigera sp., Cladina mitis and Cetraria cuculata.

The scrub community was located on an old glacial moraine in the western portion of the study area. The topography was undulating, with well-drained soils. Mean stand age was 65 years with a maximum of 88 years.

The burn site resulted from the 1977 fire, which burned this area severely, consuming most of the organic mat and exposing mineral soil. Although some dead trees remained standing on this 3-year-old site, many were completely consumed. Shrub species were essentially nonexistent. Herbaceous plant cover was almost five times that on the unburned site and consisted primarily of fireweed and Calamagrostis canadensis. The composition of the cryptogam layer was completely different since feathermoss, Cladonia mitis, Cetraria cuculata, and Peltigera sp. were non-existent. Dominant species on the burn consisted of ground moss and Marchantia polymorpna.

Open Low Shrub Scrub. The unburned open low-scrubland community was dominated by dwarf birch with an average height less than 1 m and a canopy cover of 56%. Scattered black spruce were distributed throughout the site, with less than 1% cover.

Herbaceous species, mainly Calamogrostis canadensis made up a small percentage (12.3%) of the plant cover. The Cryptogam layer consisted primarily of mosses and lichens (Cladina sp. and Cetraria culculata).

Both the 1977 and 1972 fires burned portions of this plant community, providing 3 and 8-year-old sites for comparison. Fire severity was estimated as high, particularly on the 1977 burn. All trees were killed during both fires but remained standing. On the 3-year-old site total shrub cover was much less than on the burned 8-year-old site, where shrub cover was within 25% of the pre-burn levels. As a result of the fire, herbaceous plant cover was greater compared with that on the unburned site. Fireweed was most abundant on the 3-year-old site with 68% cover, and graminoids mixed with fireweed were most abundant (22%) on the 8-year-old site. Feather moss and lichens were nonexistent on both burn sites, with ground moss the most abundant species in the cryptogam layer.

Open Dwarf Shrub Scrub. Open dwarf shrub scrub consisted primarily of low-growing shrubs (less than 20 cm) associated with sedges, herbs and mosses. Few trees were available for aging but those present were 1 to 1.5 m tall with a mean age of 39 years and a maximum of 68 years. The most abundant shrubs were: dwarf birch, cranberry, Labrador tea, willow, and blueberry. Herbaceous species were abundant including: tussocks of *Eriophorum* sp., *Carex* sp., *Petasites fridgidus* and *Equisetum arvense*. The cryptogam layer consisted of feathermoss, *Spagnum* sp., *Polytricum* sp., *Peltigera* sp., and several species of lichens.

The dwarf shrub scrub community was burned by both the 1977 and 1972 fires. On the 1977 burn, severity was estimated as high, the fire consuming much of the organic mat and leaving numerous charred sedge tussocks standing. Total shrub cover was lowest on the burned site compared to the unburned site. Shrub cover was greater on the 8-year-old site than on the 3-year-old site, but was still less than on the unburned site. Herbaceous species followed the same trend as the shrubs, with total cover less on the burned site. Although total herbaceous cover was less on the burned site, *Eriophorum* sp. cover was greater on the burned site. Composition for the cryptogam layer again showed a marked difference between sites, with feathermoss less abundant and ground moss more abundant on the burned sites.

Avian Communities

Density and diversity. Composition and density estimates for bird species on unburned and recently burned sites in 5 plant communities examined at Bear Creek are presented in Table 2. A summary analysis of avian communities is presented in Table 3. Avian densities in all 5 plant communities were higher on unburned sites than on recently burned sites. In both the needleleaf forest and low shrub scrub communities, densities on unburned sites were more than twice that of those on the recently burned site.

Species richness (number of species) was also highest on the unburned sites excluding the dwarf shrub scrub community where species richness was greatest on the most recently burned site. Avian communities that supported high densities also supported a high number of species. Figure 2 illustrates the logarithmic relationship between species richness and density ($r = 0.96$, $P > 0.01$). Spindler and Kessel (1980) showed a similar relationship in habitats in the Tanana River Valley, Alaska.

The Shannon-Weaver Index (H') was also used to compare avian community diversity (Shannon and Weaver, 1949), and followed a pattern similar to that of species richness. MacArthur and

MacArthur (1961) and Krichner (1972) felt that a diversity index which took into account both species richness and the abundance of species was a better measure of diversity than just species richness. Our analysis showed species richness to be highly correlated with the diversity index (H')($r = 0.95$, $\underline{P} < 0.005$), and we felt that either was adequate for describing avian community diversity.

Investigators in other parts of Alaska and elsewhere have obtained similar results. Quinlan (1979) studying the effects of fire on birds in white spruce forest on the Kenai Peninsula, Alaska, also found greater density and diversity on mature sites than on recently burned sites. Kessler (1979) looking at bird population responses to clearcutting in Southeast Alaska also noted higher density and diversity on undisturbed sites. Similar results were noted in mixed-coniferous forest in northern Arizona (Franzreb and Ohmart 1978).

Investigations in areas outside Alaska showed some different patterns. Taylor and Barmore (1980), studying post-fire succession of avifauna in coniferous forests of Yellowstone and Grand Teton National Parks noted higher avian densities 7 to 29 years following fire. Bock and Lynch (1970) working in coniferous forests in Sierra Nevada, also noted higher density on the recently burned site. However, in Bock and Lynch's study the fire spared a number of mature trees, resulting in a mixture of the original unburned forest and the post-fire vegetation that allowed bird species which usually occurred in mature forest to use the burned site also.

Community overlap. Estimates of the density and richness of avian communities were used to determine the degree of overlap (similarity) between avian communities of unburned and recently burned sites within each plant community and also between sites of different communities (Table 4). This was calculated using Horn's Index of "Overlap" (R_o), a derivative of the Shannon-Weaver Formula (Horn 1966). Indexes of overlap vary from 0, when bird communities are completely distinct (no species in common), to 1 when bird communities are identical with respect to proportional species composition. The greatest overlap (between burned and unburned) occurred within open low shrub scrub and open dwarf shrub scrub. In open low shrub scrub, the 3-year-old burn and 8-year-old burn showed a similarity to the unburned site of 87.0% and 84.6% respectively. The 8-year-old site in the dwarf shrub community showed a 97.7% similarity to the unburned site, but the 3-year-old site showed only a 48.8% similarity. Overall, bird communities in both open low and dwarf scrub communities showed a relatively high degree of overlap between all burned and unburned sites.

The lowest amount of overlap between recently burned and unburned sites occurred in forest communities in general (62.0% for closed mixed forest and 44.6% for open needleleaf forest) and in closed low shrub scrub containing small islands of forest-type vegetation (65.1%).

Species composition. Thirty-seven species of birds are represented in the bird data (Table 2). An additional 26 bird species were observed within the study area, but were not observed along transects during the sampling periods. Scientific names of all birds observed are listed in Appendix A. White-crowned sparrow, savannah sparrow, and tree sparrow were the 3 most species and together made up 43% of all avifauna.

Species composition varied dramatically among recently burned and unburned sites due to individual species response. The occurrence of birds in terms of individual species' foraging methods was closely associated with the nature of the vegetation on recently burned and unburned sites (Table 5). Birds that forage in trees and tall shrub foliage were most abundant on the unburned sites.

Tree-foliage searchers such as the boreal chickadees, pine grosbeak, ruby-crowned kinglet, white-winged crossbills and black-poll warblers were restricted almost entirely to unburned sites. Hagar (1960), Bock and Lynch (1970), Niemi (1978) and Quinlan (1979) also found tree-foliage species less abundant on recently burned sites.

Tree foliage searchers occurred in very low numbers within all non-forested communities, except for the unburned site in close low scrub habitat, where they made up approximately 10% of the avifauna. Tree-foliage species were absent in all recently burned non-forested sites.

Timber drillers were represented by only the northern three-toed woodpecker. In closed mixed forest, this species was found in essentially equal abundance on both burned and unburned sites; however, in the open spruce forest, it was found only on the unburned site. Quinlan (1979), assumed this species neither gained nor lost habitat through fire. Franzreb (1977) found that northern three-toed woodpeckers did not differentiate between logged and unlogged plots. Many trees at Bear Creek which were killed by fire remained standing. These trees could result in an increase in bark-beetle availability, and provide an excellent food source for woodpecker.

Aerial foragers such as the alder flycatcher benefitted from fire, being 28% more abundant on the recently burned closed mixed forest than on the unburned site. Alder flycatchers are generally considered a scrubland species (Spindler and Kessel 1980. Their occurrence on the unburned forested site was probably associated with the vegetation edge along the perennial stream. The greater number of flycatchers on the burn may have been due to the more open habitat created by the fire, further facilitating fly-catching maneuvering, as suggested by Franzreb and Ohmart 1978). Kilgore (1971) observed that flycatching species tend to be more abundant in "open" habitat and to decrease with the closing of the vegetation. The olive-sided flycatcher also occurred in closed mixed forest and was most abundant on the unburned site. Spindler and Kessel (1980) found olive-sided flycatchers only in forest communities and likewise our data probably further supports the bird's preference for more "closed" forest communities in contrast to the alder flycatcher, generally a scrubland-dweller.

Ground-bush foragers were a major guild of birds in all plant communities, both burned and unburned. The effect fire had on these species varied depending on the habit they occupied and the particular species being considered. In forested communities, ground-bush foragers were more abundant on burned sites than unburned sites. Species such as the tree, white-crowned, chipping and Lincoln's sparrows were much more abundant on recently burned forest sites. Quinlan (1979), in her study in forested habitats found the white-crowned sparrow nested only on recently burned sites. Kilgore (1971) and Spindler and Kessel (1980) also observed that ground-bush foragers seemed most abundant in open, non-forest habitats.

Although ground-bush foragers as a whole were most abundant on burned sites in forest communities, some ground-bush foragers occurred in much lower numbers on burned sites. The Swainson's thrush, varied thrush, and spruce grouse were found almost entirely on the unburned sites. Quinlan (1979) also noted that these species were most abundant on unburned areas. Bent (1932), Gabrielson and Lincoln (1959), Johnsgard (1973), and Ellison (1975) all considered spruce grouse to be adversely affected by fire.

In non-forested habitats, ground-bush foragers dominated both burned and unburned sites and contributed 88 to 100% of the avifauna. Some ground-bush foragers which were most abundant on recently burned sites in forested communities were less abundant on recently burned sites in non-forested habitats. The tree sparrow, which benefitted from fire in both open needleleaf and mixed forest, was less abundant on burned sites than unburned sites in low and dwarf shrub scrub communities. The Savannah sparrow, which was a dominant ground-bush forager in both low and dwarf open shrubland habitats, was also less abundant on recently burned sites.

Sharp-tailed grouse were found only on burned open low scrubland sites. Weeden (1965) concluded that these grouse are the first upland game birds to occupy recent burns and remain as long as an "open" vegetation persists. Likewise, Cringan (1958) and Aldrich (1963) suggest that sharp-tailed grouse in the northern zones require recently burned areas.

Some species, such as the dark-eyed junco, showed no consistent preference for either burned or unburned habitats. Franzreb (1977) and Kessler (1979) found that the junco was considerably more abundant on logged areas, while Quinlan (1979) found that this species was unaffected by fire in needleleaf forests. In our study, junco numbers were lower in abundance on burned needleleaf forest and closed low shrub scrub sites, but remained essentially equal in numbers on closed mixed forest sites. The upland sandpipers also demonstrated a similar inconsistency in site selection.

Bioenergetics. Estimates of standing crop biomass (SCB) consuming biomass (CB) and existence energy (EE) have been considered important by several authors when evaluating avian communities (Salt 1957; Kendeigh 1970; Karr 1971 and Spindler and Kessel 1980). SCB, the total weight of avifauna in a community, was calculated from breeding season bird weights obtained from the University of Alaska Museum, Nice (1964); and Spindler and Kessel (1978) (Appendix B). CB was calculated by adjusting the weight of passerine birds to the .566 power and non-passerine birds to the .618 power, i.e., $W^{.566}$ and $W^{.618}$. Spindler and Kessel (1980) used .76 while Karr (1968) and Salt (1957) used 0.7 power. However, these values appeared high based on our calculations (see below). EE was calculated after Kendeigh (1970), who presented an equation for existence metabolism at 30°C and 0°C. Mean daily temperature during our sample period was 11.7°C. The equations used for our EE estimates, based on interpolation of Kendeigh's equation were as follows:

Passerines:
$$\text{Log EE} = 0.4653 + 0.5655 \log W$$

Non-Passerines:
$$\text{Log EE} = 0.2844 + 0.6176 \log W$$

where EE = Kcal consumed per bird per day and W = weight in grams (individual). Karr (1968) points out several limitations to this estimate and states that actual EE values may be twice that of the estimate.

SCB, CB and EE showed the same trends as avifauna density and diversity figures (Table 3). In forested and low shrub scrub communities, all three estimates of bioenergetics were higher on the unburned sites than on the recently burned sites. However, in open dwarf scrubland, bioenergetics estimates were highest on the most recently burned site. The higher values on the recently burned site were attributed to the presence of a large number of heavy-bodied sandpipers, which occurred only on this unburned site. Bock and Lynch (1970) noted that on the average, individual birds were heavier on the burned plot. At Bear Creek, we found the average weight of all individuals per area were highest on the 3-year-old burn sites but lower on the older 8-year-old burn sites.

DOMINANCE

A Dominance Index (DI) was calculated for each unburned and recently burned area at Bear Creek (Table 3). DI was defined as the concentration of influence in the two most abundant species and calculated as:

$$DI = 100\ (Y_1 + Y_2)\ /\ Y$$

where Y_1 and Y_2 = the density of species 1 and 2, and Y = the total density of all species in the community (McNaughton and Wolf 1970). In habitats with small breeding populations, dominance is generally related to the number of breeding species, i.e. high dominance values associated with low species-diversity (Weins and Dyer 1975). On unburned and recently burned sites at Bear Creek, DI values were strongly correlated to both species richness and density, $r = 0.94$ $P < 0.005$ and $r = 0.69$ $P < 0.025$ respectively.

Density-dominance structures for bird communities at Bear Creek illustrate that individual birds were concentrated in fewer species (higher dominance values) on recently burned sites in forested and low shrub scrub communities compared to the more species-rich unburned sites (Fig. 3). In dwarf shrub scrub, the reverse was true, with the higher dominance value for the unburned sites.

Comparing sites in all plant communities, we found DI values in open habitats (burned and unburned shrub scrub), indicating that the bird communities on these sites were strongly dominated by a few species. The only exception to this was in closed mixed forest, where the DI value (37.1) remained relatively low on the recently burned site. This was obviously related to the high density and species richness supported by both unburned and recently burned sites.

McNaughton and Wolf (1970) showed that dominance in avian communities was related to the harshness of the environment, where the more strongly dominated the community (higher dominance values), the harsher the environment. Harshness refers to those conditions which limit the number of species a habitat can support. If higher dominance does reflect harsher conditions, then our results indicate that recently burned sites in forest and low scrubland are harsher than the unburned habitat, and that open habitats in general are harsher than forest habitats. Karr (1971) assumed that structurally less complex habitats represented harsher environments and noted a trend of lower dominance values with the vegetation development, i.e. open to closed habitats.

Habitat Structure and Species Diversity. The ability of an area to provide requisites for avian species is based largely on the structure of the habitat (Balda 1975). Major factors which make up habitat structure include: layers of vegetation, life form, height and amount of vegetation, and the presence of structural features, such as snags, water bodies, etc. As the structure of a habitat becomes more complex, i.e. increased in the number and diversity of habitat components, there is an increased opportunity for additional species to occupy an area (Meslow 1978). Measures of habitat structure and complexity have been correlated with species richness and diversity by numerous investigators (Johnson and Odum 1956, McArthur 1964, Karr 1968, Recher 1969, Shugart and James 1973, Meslow and Wight 1975, Balda 1975, Spindler and Kessel 1980). Spindler and Kessel (1980) also noted that species richness increased in habitats with high productivity.

At Bear Creek, vertical structure diversity (VSD') was highly correlated with species richness and diversity ($r = 0.841$, $\underline{P} < 0.005$ and $r = 0.730$ $\underline{P} < 0.025$ respectively). Highest VSD' values occurred in unburned forest and closed low shrub scrub containing islands of forest and tall shrub vegetation. The greater complexity (increase in number of vegetation layers) on unburned sites compared to recently burned sites resulted in both an addition to an an expansion of foraging guild (the addition of foliage searchers and timber dwellers, and expansion of ground-bush foragers). Spindler and Kessel (1980) also observed an increased species richness through guild addition and expansion with an increase in structural complexity. However, they also noted an increase in species richness in habitats with high productivity. In open low shrub scrub, species diversity through guild expansion was increased on the unburned site with higher foliage density and shrub cover, measures related to total biomass and production. The unburned site probably provided a greater food supply as well as increased cover for nesting.

Although overall species richness and diversity was correlated with VSD on some sites, this relationship did not hold true on all sites. In dwarf shrub scrub, both species richness and diversity were highest on the most recently burned site while VSD was greatest on the unburned site. In open low shrub scrub, VSD was greater on the 8-year-old site, while species richness and diversity was highest on the unburned site. However, both unburned and recently burned sites in open low and dwarf shrub scrub were structurally more simple sites, consisting primarily of one low-growing vegetation layer. It is possible that in relatively simple habitats, the relationship between habitat complexity and species richness does not always hold true. Wilson (1974) similarly noted that the composition of bird species in less complex grassland habitat was not related to measures of habitat complexity and that the avifauna of grasslands generally differed more among themselves that did forest communities.

Spindler and Kessel (1980) noted that the presence of water enhanced species richness, resulting in the addition of the aquatic foraging guild. At Bear Creek, the presence of water also had the same influence on species richness and diversity. In closed mixed forest, an adjacent permanent stream provided habitat for the northern waterthrush, rusty black bird and greater yellowlegs.

On the recently burned closed mixed forest site, the combination of the water and unburned alder patches along the stream bank helped maintain a relatively high diversity of birds, even though the number of vegetation strata was reduced by fire. Also, the presence of unburned islands allowed species such as the alder flycatcher, dark-eyed junco, fox sparrow, yellow-rumped warbler and northern waterthrush to remain abundant on the burn site. Bock and Lynch (1970) and Conner and Adkissen (1975) also noted a similar influence on unburned islands on use by a variety of species.

ACKNOWLEDGEMENTS

We thank Mark Collie, Larry Mangan, Lynn Sickles and Bill Hanson, of the Bureau of Land Management, Alaska, for their help during the field portion of the study. We also thank Dr. Brina Kessel, University of Alaska; Dr. Robert Ohmart, University of Arizona; Dr. B.J. Verts and Dr. Robert Jarvis, both of the Oregon State University; and Dr. Dale Taylor and Dr. William Gabriel, both of the Bureau of Land Management, Alaska for their constructive criticism and review of the manuscript. This study was funded by the Bureau of Land Management, Alaska, as part of the Bear Creek fire effects program.

LITERATURE CITED

Aldrich, J.W. 1963. Geographic orientation of American Tetronidae. J. Wildl. Mgmt. 27:524-55.

Balda, R.P. 1975. Vegetation structure and breeding bird diversity. Proc. Symp. Mgmt. for. and range hab. for nongame birds. U.S.D.A. For. Serv. Gen. Tech. Rept. WO-1:59-80.

Barney, R.J. 1971. Selected 1966-69 interior Alaska wildfire statistics, with long term comparisons. U.S.D.A. For. Serv., Pacific N.W. For. and Range Exp. Stn., Portland Oregon. Res. Note PNW-154. 13 pp.

Bendell, J.F. 1974. Effects of fire on birds and mammals. In fire and ecosystems, Kozlowski, T.T. and C.E. Ahlgken (eds.) 1974. pp. 73-138.

Bent, A.C. 1932. Life histories of North American gallinaceous birds. Bull. U.S. Nat. Muns. No. 162. 490 p.

Bock, C.E. and J.F. Lynch. 1970. Breeding bird populations of burned and unburned coniferous forests in the Sierra Nevada. Condor 72:182-189.

Breakenridge, W.J. 1935. A bird census method. Wilson Bull. 47:195-197.

Carbyn, L.M. 1971. Densities and biomass relationships of birds nesting in boreal habitats. Arctic 24:51-61.

Conner, R.N. and C.S. Adkissen, 1975. Effect of clearcutting on the diversity of breeding birds. J. of For., Vol. 73:781-785.

Cringan, A.T. 1958. The influence of forest fires and fire protection on wildlife. Forestry Chron. 34(1): 25-30.

Daubenmire, R. 1959. A canopy-coverge method of vegetation analysis. Northwest Sci. 33:43-64.

Ellison, L.N. 1975. Density of Alaskan spruce grouse before and after fire. J. Wildl. 39(3):468-471.

Emlen, J.T. 1969. Habitat selection by birds following a forest fire. Ecology 51(2):343-345.

Emlen, J.T. 1977. Estimating breeding season bird densities from transect counts. Auk 94:455-468.

Enemark, A. 1959. On the determination of the size and composition of a passerine bird population during the breeding season. in Carbyn, L.M. 1971. Densities and biomass relationships of birds nesting in boreal habitats. Arctic 24:51-61.

Franzreb, K. 1977. Bird population changes after timber harvesting of mixed coniferous forest in Arizona. U.S.D.A. For. Serv. Res. Pap. RM-184. 26 p.

Franzreb, Kathleen E., and Robert D. Ohmart. 1978. The effects of timber harvesting on breeding birds in a mixed-coniferous forest. Condor 80:431-441.

Gabrielson, I.N., and F.C. Lincoln. 1959. Birds of Alaska. Stackpole Co. Harrisburg, Penn. 922 p.

Haapanen, A. 1965. Bird fauna of Finnish forests in relation to forest succession. I. Annales Zoologici 2:153-196.

Hagar, D.C. 1960. Inter-relationships of logging, birds, timber regeneration in the douglas-fir region of northern California. Ecology 41(1):116-125.

Horn, Henry S. 1966. Measure of "overlap" in comparative ecological studies. AM. Nat. 100:914.

Johnsgard, P.A. 1973. Grouse and quail of North America. U. Nebraska press, Lincoln. 533p.

Johnston, Davis W. and Eugene P. Odum. 1956. Breeding bird populations in relation to plant succession on the Piedmont of Georgia. Ecology 37:50-62.

Karr, J.R. 1968. Habitat and avian diversity on strip-mined land in east Illinois. Condor 70:348-357.

Karr, J.R. 1971. Structure of avian communities in selected Panama and Illinois habitats. Ecol. Monogr. 41:207-233.

Kendeigh, S.C. 1970. Energy requirements for existence in relation to size of bird. Condor 72:60-65.

Kessler, Winifred B. 1979. Bird population response to clearcutting in the Tongass Nat. For. of Southeast Alaska. U.S.D.I. For. Serv., Ak. Region Rep., No. 71.

Kilgore, B.M. 1971. Response of breeding bird population to habitat changes in giant sequoia forest. Amer. Midl. Nat. 85:135-152.

Krichner, J.C. 1972. Bird species diversity: The effects of species richness and equitability on the diversity index. Ecology 53:278-282.

Lawrence, G.E. 1966. Ecology of vertebrate animals in relation to chapparral fires in Sierra Nevada foothills. Ecology 47:278-291.

Lowe, Phillip O., Peter F. Ffolliott, John H. Dieterich, and David Patton. 1978. Determining potential wildlife in Arizona ponderosa pine forests. For. Ser. Gen. Tech. Rep. RM-52.

MacArthur, R.H. and J.W. MacArthur. 1961. On bird species diversity. Ecology 52:594-598.

MacArthur, R.H. 1964. Environmental factors affecting bird species diversity. Amer. Nat. 98:387-397.

Marshall, J.T., Jr. 1963. Fire and birds in the mountains of southern Arizona. Proc. Tall Timbers Fire Ecol. Conf. 2:135-141.

McNaughton, S.J. and L.L. Wolf. 1970. Dominance and the niche in ecological systems. Science 167:131-167.

Meslow, E. Charles. 1978. The relationship of birds and habitat structure, plant communities and successional stages. Presented at the workshop on nongame bird habitat management in Conf. Trust of the Western U.S., Portland, Oregon, Feb 7-9, 1977.

Meslow, E.C. and H.M. Wight. 1975. Avifauna and succession in douglas-fir forest of the pacific northwest. Proc. symp. mgmt. forest and range habitats for non-game birds. USFS gen. tech. report. WO-1. 342 pp.

Nice, N.M. 1964. Studies in the life history of the song sparrow. in Carbyn, L.M. 1971. Densities and biomass relationships of birds nesting in boreal habitats. Arctic 24:51-61.

Niemi, Gerald J. 1978. Breeding birds of burned and unburned areas in northern Minnesota. Loon 50:73-84.

Noble, R.E. 1977. Breeding bird population in hemlock-spruce, old-growth and clearcuts, Prince of Wales island, Alaska. U.S. For. Ser. Rep., Tongass Nat. For., Ketchikan, 73 p.

Nudds, Thomas D. 1977. Quantifying the vegetation structure of wildlife cover. Wildl. Soc. Bull. 5,: 3, Fall.

Odum, E.P. 1971. Fundamentals of ecology. W.B. Sanders Co., Philadelphia. 574 pp.

Palmgren, P. 1930. Quantitative Untersuchungen Uber Die Vogelfauna in den Waldren Sudfinnlands. in Emlen, J.T. 1977. Estimating breeding birds derived from transect counts. Aux 94:455-468.

Quinlan, S.E. 1979. Bird communities and white spruce succession on the Kenai Peninsula. Unpublished report. Chugach Nat. For., Seward, Ak.

Recher, H.F. 1969. Bird species diversity and habitat diversity in Australia and Norther America. Amer. Nat. 103:75-80.

Salt, George W. 1957. An analysis of avifaunas in the Teton Mountains and Jackson Hole, Wyoming. Condor, Vol 59, pp. 373-393.

Shannon, C.E. and W. Weaver. 1949. The mathematical theory of communication. Univ. of Ill. Press, Urbana. 117 p.

Shugart, H.H. and D. James. 1973. Ecological succession of breeding population of birds on farmland. Bird study 12:287-304.

Spindler, Michael A. and Brina Kessel. 1980. Avian populations and habitat use in interior Alaska. Taiga. Syesis. Vol. 13:61-104.

Spindler, Michael A. and Brina Kessel. 1978. Terrestrial avian habitats and their utilization Upper Tanana River Valley, Alaska. Prepared for Northwest Alaskan Pipeline Company, May 1978.

Taylor, D.L. and W.J. Barmore, Jr. 1980. Post fire succession of avifauna in coniferous forests of Yellowstone and Grand Teton National Parks, Wyoming. in Proc. of the symp. of mgmt. of western for. and grasslands for non-game birds (Feb. 1980, Salt Lake City, Utah). Tech. Rep. INT-86, U.S.D.A., For. Ser. pp. 130-145.

Viereck, L.A. 1973. Wildfire in the Taiga of Alaska. Quat. Res. 3:465-495.

Viereck, Leslie A. and C.T. Dyrness. 1982. A preliminary classification system for vegetation of Alaska. U.S.D.A. Forest Serv. Unpl. Rep.

Viereck, Leslie A. and Linda A. Schandelmeier. 1980. Effects of fire in Alaska and adjacent Canada. A literature review. Bureau of Land Management-Alaska technical report No. 6, 124 p.

Wahraftig, C. 1965. Physiographic division of Alaska, U.S.D.I. geological survey, Professional Pap. 482.

Weeden, S.J. 1965. Grouse and Ptarmigan in Alaska. Alaska Dept. of fish and Game. Fed. Aid Wild. Rest. Proj. Rept. Vol. V., Proj. W-6-R, Work Plan I, Juneau, Alaska 110 pp.

Wiens, J.A. and M.I. Dyer. 1975. Rangeland avifaunas: Their composition, energetics, and role in ecosystem. in D.R. Smith, ed. Proc. Symp. mgt. forest and range habitats for non-game birds. (May 1975, Tucson, AZ). Tech. Rep. WO-1 U.S. For. Ser. Washington, D.C., pp. 146-182.

Wilson, M.F. 1974. Avian community organization and habitat structures. Ecology 55:1017-1029.

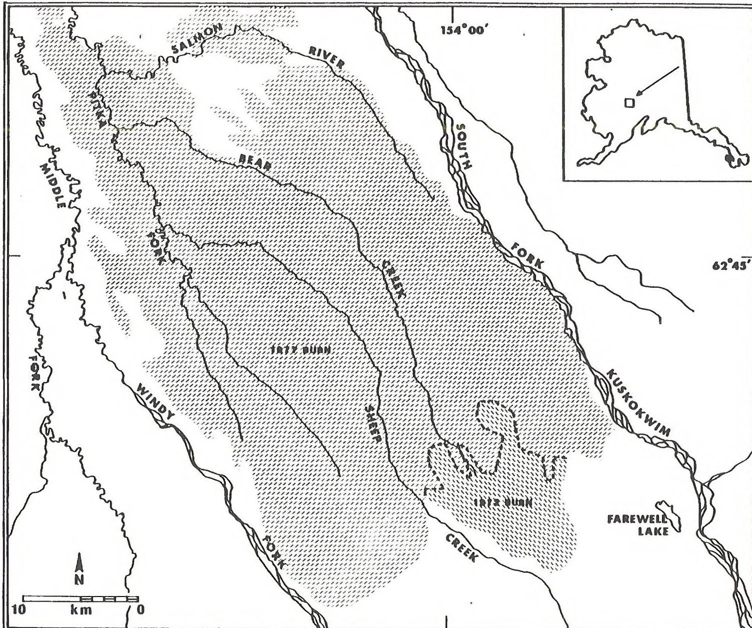

Figure 1. Location of the Bear Creek study area in interior Alaska.

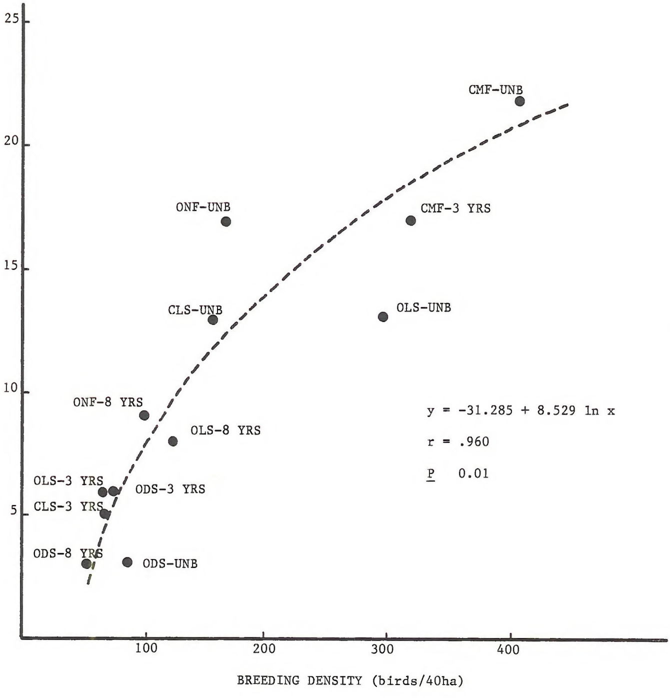

Figure 2. Logarithmic relationship between density and species richness for habitats in interior Alaska. CMF = Closed Mixed Forest, UNB = Unburned, ONF = Open Needleleaf Forest, CLS = Closed Low Shrub Scrub, OLS = Open Low Shrub Scrub, ODS = Open Dwarf Shrub Scrub, 3 YRS = 3 years old, 8 YRS = 8 years old.

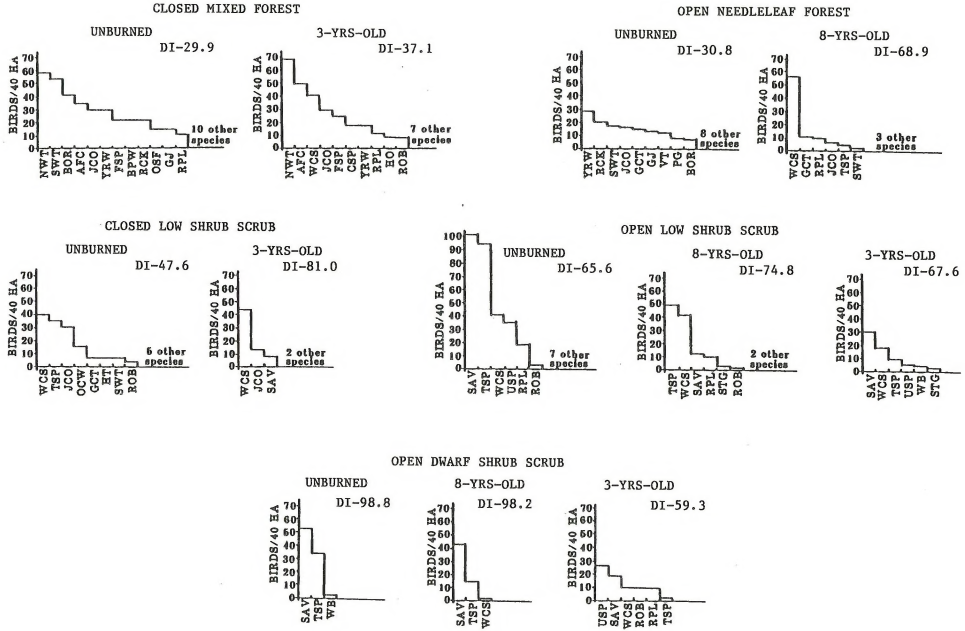

Figure 3. Density-dominance structues of avian communities in unburned and recently burned habitats in interior Alaska.

Table 1. Vegetation analysis for recently burned and unburned habitats in interior Alaska[a].

VARIABLE	CMF		ONF		CLS		OLS			ODS		
	UNB	3-yrs	UNB	8-yrs	UNB	3-yrs	UNB	8-yrs	3-yrs	UNB	8-yrs	3-yrs
Ground Cover (%)												
Shrub Layer	38.8	0.2	25.2	33.9	97.5	0.8	64.5	49.2	0.2	60.1	41.7	11.0
Bare Ground	0.0	7.5	0.0	0.0	0.0	5.8	0.0	0.0	2.3	5.2	0.0	0.0
Persistent Litter	7.8	33.0	4.7	25.4	9.5	31.0	11.2	1.8	13.4	4.1	9.2	78.8
Litter	48.4	31.8	10.0	36.2	18.3	12.2	15.5	39.8	27.3	33.0	17.0	4.1
Bare Rock	0.0	0.0	0.1	0.1	0.0	3.3	0.0	0.0	0.6	0.0	0.0	0.0
Water	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0	7.8
Mosses, Lichens, Fungi and Liverworts	27.7	40.2	80.8	30.1	58.2	48.0	69.5	36.7	61.8	28.7	59.4	33.1
Herbaceous Layer	83.8	39.8	23.3	50.1	12.3	59.1	5.8	21.8	71.8	52.8	31.7	19.9
Vertical Structure Distribution (Frequency)												
>4.5 m	NO DATA		5.7	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.2 - 4.5 m			14.9	1.8	1.0	0.8	0.0	0.4	0.0	0.0	0.0	0.0
0.6 - 1.2 m			9.2	9.2	3.9	1.7	2.2	1.1	1.3	0.0	0.0	0.0
0.3 - 0.6 m			12.1	22.7	16.9	3.3	18.0	26.4	6.0	8.7	0.8	0.0
<0.3 m			58.0	66.3	77.2	94.2	79.8	72.1	92.7	91.3	99.2	100.0
Diversity (H')			1.201	0.904	0.714	0.276	0.573	0.759	0.295	0.294	0.044	0.000
Evenness (J')			0.769	0.650	0.447	0.200	0.521	0.476	0.269	0.427	0.068	0.000
Tree Diameter (cm)	25-30	25-30 (Dead)	10-20	10-20 (Dead)	10-15	10-20 (Dead)	8-13	8-13 (Dead)	13-20 (Dead)	3-5	5-8 (Dead)	5-8 (Dead)
Tree Height (m)	15-18	17-20 (Dead)	6-12	6-10 (Dead)	1-3	3-5 (Dead)	1-3	1-4 (Dead)	3-5 (Dead)	1-2	1-2 (Dead)	1-2 (Dead)
Tree Canopy Cover (%)	70	<1	50	<1	5	0	<1	0	0	<1	0	0
Stand Age (Years)												
Mean	121	3	103	8	65	3	69	8	3	39	8	3
Maximum	178		154		88		120			68		
Foliage Volume (Density Each Class)												
1.2 - 3.6 m	NO DATA		61.0	20.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.6 - 1.2 m			62.0	28.0	14.4	0.0	0.0	1.4	0.0	0.0	0.0	0.0
0.3 - 0.6 m			57.3	52.0	75.8	12.5	44.8	23.8	2.5	13.8	0.0	0.0
< 0.3 m			67.8	79.5	92.0	59.8	74.3	97.4	52.5	66.0	13.8	13.8

[a]CMF = Closed Mixed Forest; ONF = Open Needleleaf Forest; CLS = Closed Low Shrub Scrub; OLS = Open Low Shrub Scrub; ODS = Open Dwarf Shrub Scrub; UNB = Unburned; 8-yrs = 8-year-old site; 3-yrs = 3-year-old site.

Table 2. Avian census results for recently burned and unburned habitats in interior Alaska.[a] Densities are mean values given as birds per 40 ha (100 acres). "P" denotes a species presence on the transect, but outside the 60 m used for density estimations.

Species Abbreviation	Foraging Method(b)	CMF		ONF		CLS		OLS			ODS			HABITAT USE	
		UNB	3-yrs	UNB	8-yrs	UNB	3-yrs	UNB	8-yrs	3-yrs	UNB	8-yrs	3-yrs	n	HUD'[c]
Alder Flycatcher (AFC)	F	35.5	49.4	--	--	P	--	P	--	--	--	--	--	4	0.790
American Robin (ROB)	GBF	5.9	9.2	2.9	1.8	4.5	2.9	1.8	1.9	--	--	--	9.8	9	1.998
Blackpoll Warbler (BPW)	FS	23.7	--	--	--	--	--	--	--	--	--	--	--	1	0.0
Bohemian Waxwing (BOH)	GBF	P	--	1.5	--	--	--	--	--	--	--	--	--	2	0.673
Boreal Chickadee (BOR)	FS	41.4	--	7.8	--	--	--	--	--	--	--	--	--	2	0.437
Chipping Sparrow (CSP)	GBF	18.5	--	--	--	--	--	--	--	--	--	--	--	1	0.0
Common Flicker (FLK)	GBF	--	--	--	--	P	--	--	--	--	--	--	--	1	0.0
Dark-eyed Junco (JCO)	GBF	29.6	30.8	17.3	7.2	31.8	14.2	P	--	--	--	--	--	7	1.720
Fox Sparrow (FSP)	GBF	23.7	24.7	--	--	P	--	P	--	--	--	--	--	4	0.860
Gray-checked Thrush (GCT)	GBF	2.9	--	15.0	11.2	8.5	--	--	P	--	--	--	--	5	1.349
Gray Jay (GJ)	MGF	17.7	P	14.9	--	P	--	--	--	--	--	--	--	4	0.991
Greater Yellowlegs (YL)	AF	--	6.1	--	--	--	--	--	--	--	--	--	--	1	0.0
Hawk Owl (HO)*	R	--	9.2	--	--	--	--	--	--	--	--	--	--	1	0.0
Hermint Thrush (HT)	GBF	P	--	--	--	8.5	--	--	P	--	--	--	--	3	0.619
Lincoln's Sparrow (LSP)	GBF	--	6.1	--	--	--	--	--	--	--	--	--	--	1	0.0
Marsh Hawk (MN)*	R	--	--	--	--	--	--	P	--	--	--	--	--	1	0.0
Northern Three-toed (NWP)	TD	5.9	6.1	1.8	--	--	--	--	--	--	--	--	--	3	0.990
Northern Water Thrush (NWT)	AF	59.2	67.9	--	--	--	--	--	--	--	--	--	--	2	0.691
Olive-sided Flycatcher (OSF)	F	17.7	6.1	P	--	--	--	--	--	--	--	--	--	3	0.715
Orange-crowned Warbler (OCW)	FS	--	--	--	--	16.4	--	--	--	--	--	--	--	1	0.220
Pine Grossbeak (PG)	FS	P	--	7.9	--	--	--	--	--	--	--	--	--	2	0.351
Redpoll Species (RPL)	GBF	11.8	12.3	3.3	10.8	P	P	17.6	10.8	--	--	--	9.8	9	1.962
Red-tailed Hawk (RTH)*	R	P	--	--	--	--	--	--	--	--	--	--	--	1	0.0
Ruby-crowned Kinglet (RCK)	FS	23.7	--	20.9	--	--	--	--	--	--	--	--	--	2	0.691
Rusty Blackbird (RBB)	AF	5.9	--	--	--	--	--	--	--	--	--	--	--	1	0.0
Savannah Sparrow (SAV)	GBF	--	--	--	--		9.4	102.8	13.3	29.4	50.2	41.7	19.7	7	1.675
Sharp-tailed Grouse (STG)*	GBF	--	--	--	--	--	--	--	2.6	2.5	--	--	--	2	0.693
Spruce Grouse (SG)*	GBF	--	--	4.0	--	--	--	--	--	--	--	--	--	1	0.0
Swainson's Thrush (SWT)	GBF	53.3	P	17.8	3.0	8.5	--	--	--	--	--	--	--	5	1.021
Tree Sparrow (TSP)	GBF	--	6.1	--	5.7	35.8	--	92.2	48.1	8.9	33.4	13.9	P	9	1.725
Upland Sandpiper (USP)	GBF	--	--	--	--	--	--	35.1	--	5.9	--	--	24.6	3	0.914
Varied Thrush (VT)	GBF	5.9	--	12.7	P	--	--	--	--	--	--	--	--	3	0.794
Whimbrel (WB)*	GBF	--	--	--	--	--	--	P	--	5.5	P	--	--	3	0.765
White-crowned Sparrow (WCS)	GBF	--	43.2	5.3	57.3	39.8	42.5	40.6	42.9	17.9	--	P	9.8	10	2.058
White-winged Crossbill (WWCB)	FS	--	--	3.1	--	--	--	--	--	--	--	--	--	1	0.0
Yellow-rumped Warbler (YRW)	FS	29.6	18.5	29.4	P	--	--	P	--	--	--	--	--	5	1.185
Yellow Warbler (YW)	FS	5.9	--	--	--	--	--	--	--	--	--	--	--	1	0.0

a. CMF = Closed Mixed Forest; ONF = Open Needleleaf Forest; CLS = Closed Low Shrub Scrub; OLS = Open Low Shrub Scrub; ODS = Open Dwarf Shrub Scrub; UNB = Unburned; 8-yrs = 8-year-old site; 3-yrs = 3-year-old site.

b. Foraging method: F = Flycatcher; FS = Foliage Searcher; TD = Timber Driller; GBF = Ground Bush Forager; R = Raptor; AF = Aquatic Feeder; MGF = Multi Guild Feeder.

c. HUD' = Habitat Use Diversity.

Table 3. Analysis of avian communities of recently burned and unburned habitats in interior Alaska.

Plant community/site	Area Size (ha)	Density (birds/ 40ha)	Standing Biomass (g/40ha)	Consuming Biomass (g/40ha)	Existence Energy (kcal/40ha	Dominance Index (%)	Diversity Species Richness	(H')	(J')
Closed mixed forest									
unburned	54.7	403.3	9633	2369	6842	29.9	22	2.661	0.861
3-year-old	52.4	316.2	7763	2194	5809	37.1	17	2.399	0.847
Open needleleaf forest									
unburned	60.1	166.6	5142	1262	3496	30.8	17	2.501	0.882
8-year-old	57.8	99.0	2428	592	1738	68.9	9	1.431	0.615
Closed low shrub scrub									
unburned	20.4	158.8	3770	907	2682	47.6	13	1.969	0.767
3-year-old	34.3	70.0	1723	412	1226	81.0	5	1.088	0.676
Open low shrub scrub									
unburned	46.1	297.1	10280	2229	5653	65.5	13	1.587	0.618
8-year-old	76.3	121.6	2507	806	2207	74.8	8	1.417	0.681
3-year-old	32.5	69.9	1980	757	1763	67.6	6	1.499	0.839
Open dwarf shrub scrub									
unburned	29.0	84.6	1501	467	1314	98.8	3	0.729	0.663
8-year-old	46.6	56.6	1023	291	849	98.2	3	0.641	0.583
3-year-old	32.9	74.7	5329	878	2081	59.3	6	1.574	0.878

Table 4. Horn's community overlap for recently burned and unburned habitats in interior Alaska.

Plant Community/site	CMF UNB	CMF 3 yrs.	ONF UNB	ONF 8 yrs.	CLS UNB	CLS 3 yrs.	OLS UNB	OLS 8 yrs.	OLS 3 yrs.	ODS UNB	ODS 8 yrs.	ODS 3 yrs.
CMF - UNB	1.000	0.629	0.675	0.257	0.300	0.185	0.087	0.083	0.000	0.000	0.000	0.122
CMF - 3 yrs.		1.000	0.352	0.536	0.476	0.534	0.290	0.386	0.258	0.082	0.108	0.297
ONF - UNB			1.000	0.446	0.404	0.311	0.122	0.159	0.087	0.000	0.022	0.160
ONF - 8 yrs.				1.000	0.746	0.770	0.511	0.709	0.445	0.128	0.165	0.421
CLS - UNB					1.000	0.651	0.510	0.668	0.412	0.305	0.275	0.283
CLS - 3 yrs.						1.000	0.562	0.645	0.600	0.243	0.335	0.535
OLS - UNB							1.000	0.835	0.870	0.846	0.853	0.792
OLS - 8 yrs.								1.000	0.729	0.629	0.612	0.551
OLS - 3 yrs.									1.000	0.724	0.775	0.689
ODS - UNB										1.000	0.967	0.418
ODS - 8 yrs.											1.000	0.507
ODS - 3 yrs.												1.000

CMF = Closed mixed forest; ONF = Open needleleaf forest; CLS = Closed low shrub scrub; OLS = Open low shrub scrub; ODS = Open dwarf shrub scrub; UNB = Unburned; 8 yrs. = 8-year-old site; 3 yrs. = 3-year-old site.

Table 5. Relative abundance and species richness ( ) by foraging method for recently burned and unburned habitats in interior Alaska.

Plant community/site	Foraging Method						
	Flycatcher	Foliage Searcher	Timber Driller	Ground-bush Forager	Raptor	Aquatic Feeder	Multi-guild forager
Closed mixed forest							
unburned	13.2 (2)	31.1 (6)	1.5 (1)	33.5 (9)	0.2 (1)	16.1 (2)	4.4 (1)
3-year-old	17.6 (2)	5.9 (1)	1.9 (1)	48 0 (9)	2.9 (1)	23.4 (2)	0.3 (1)
Open needleleaf forest							
unburned	0.6 (1)	40.5 (5)	1.1 (1)	46.7 (9)	--	--	8.9 (1)
8-year-old	--	1.0 (1)	--	99.0 (8)	--	--	--
Closed low shrub scrub							
unburned	0.6 (1)	10.4 (1)	--	88.4 (10)	--	--	0.6 (1)
3-year-old	--	--	--	100.0 (5)	--	--	--
Open low shrub scrub							
unburned	0.3 (1)	0.7 (2)	--	98.7 (9)	0.3 (1)	--	--
8-year-old	--	--	--	100.0 (8)	--	--	--
3-year-old	--	--	--	100.0 (6)	--	--	--
Open dwarf shrub scrub							
unburned	--	--	--	100.0 (3)	--	--	--
8-year-old	--	--	--	100.0 (3)	--	--	--
3-year-old	--	--	--	100.0 (6)	--	--	--

Note: Foraging methods after Spindler and Kessel (1980)

APPENDIX A. COMMON AND SCIENTIFIC NAMES OF BIRDS OBSERVED ON THE BEAR CREEK STUDY AREA

COMMON NAME	SCIENTIFIC NAME
Red-throated loon	*Gavia stellata*
Canada goose	*Branta canadensis*
Mallard	*Anas platyrhynchos*
American widgeon	*Mareca americana*
Green-winged teal	*Anas carolinensis*
Common goldeneye	*Bucephala clangula*
Harlequin duck	*Histrionicus histrionicus*
Common merganser	*Mergus merganser*
Red-breasted merganser	*Mergus serrator*
Marsh hawk	*Circus cyaneus*
Rough-legged hawk	*Buteo lagopus*
Red-tailed hawk (Harlan's)	*Buteo jamaicensis*
Spruce grouse	*Canachites canadensis*
Sharp-tailed grouse	*Pediocetes phasianellus*
Willow ptarmigan	*Lagopos lagopus*
Sandhill crane	*Grus canadensis*
Whimbrel	*Numenius phaeopus*
Upland sandpiper	*Bartramia longicauda*
Solitary sandpiper	*Tringa solitaria*
Spotted sandpiper	*Actitis macularia*
Greater yellowlegs	*Totanus melanoleucus*
Common snipe	*Capella gallinago*
Long-tailed jaeger	*Stercorarius longicaudus*
Glaucous-winged gull	*Larus glaucenscens*
Mew gull	*Larus canus*
Short-eared owl	*Asio flammeus*
Great gray owl	*Strix nebulosa*
Hawk owl	*Surnia ulula*
Belted kingfisher	*Megaceryle alcyon*
Common flicker	*Colaptes auratus*
Northern three-toed woodpecker	*Picoides tridactylus*
Alder flycatcher	*Empidona alnorum*
Olive-sided flycatcher	*Nuttallornis borealis*
Tree swallow	*Iridiprocne bicolor*
Bank swallow	*Riparia riparia*
Rough-winged swallow	*Stelgidopteryx fuficollis*
Gray jay	*Perisoreus canadensis*
Common raven	*Corvus corax*
Black-capped chickadee	*Parus atricapillus*
Boreal chickadee	*Parus hudsonicus*
Robin	*Turdus migratorius*
Varied thrush	*Ixoreus naevius*
Hermit thrush	*Hylocichla guttata*
Swainson's thrush	*Hylocichla ustulata*
Gray-cheeked thrush	*Hylocichla minima*
Mountain bluebird	*Sialia currucoides*
Ruby-crowned kinglet	*Regulus calendula*
Bohemian waxwing	*Bombycilla garrulus*

APPENDIX A (continuation)

COMMON NAME	SCIENTIFIC NAME
Orange-crowned warbler	*Vermivora celata*
Yellow warbler	*Dendroica petechia*
Yellow-rumped warbler	*Dendroica coronata*
Blackpoll warbler	*Dendroica striata*
Northern waterthrush	*Seiurus noveboracensis*
Rusty blackbird	*Euphagus carolinus*
Pine grosbeak	*Pinicola enucleator*
Hoary redpoll	*Acanthis hornemanni*
Common redpoll	*Acanthis flammea*
White-winged crossbill	*Loxia leucoptera*
Savannah sparrow	*Passerculus sandwichensis*
Dark-eyed junco	*Junco hyemalis*
Tree sparrow	*Spizella arborea*
Chipping sparrow	*Spizella passerina*
White-crowned sparrow	*Zonotrichia leucophrys*
Fox sparrow	*Passerella iliaca*
Lincoln's sparrow	*Melospiza lincolnii*
Song sparrow	*Melospiza melodia*

APPENDIX B

Breeding season bird weights used in biomass and existence energy analysis. Obtained from University of Alaska Museum: Spindler and Kessel (1978), Nice (1964), West and DeWolff (1974), and Carbyn (1971) In Spindler and Kessel

Species	Weight (grams)	Source
Alder Flycatcher	12.6	UAM (12.3), West & Dewolfe (13.6), CARBYN (12)
Bohemian Waxwing	50.3	UAM (60.6), CARBYN (58.0)
Boreal Chickadee	11.5	UAM (12.1), CARBYN (11.0)
Blackpoll Warbler	12.4	UAM (12.8), CARBYN (12.0)
Chipping Sparrow	12.1	UAM
Common Flicker	177.0	UAM
Fox Sparrow	36.6	UAM
Gray-Cheeked Thrush	29.5	UAM (30.1), CARBYN (29.0)
Gray Jay	72.3	UAM
Greater Yellowlegs	188.9	UAM
Hawk Owl	341.7	UAM
Hermit Thrush	27.0	UAM
Dark-Eyed Junco	18.6	UAM (18.4), WEST & DEWOLFE (18.5), CARBYN (19)
Lincoln Sparrow	15.8	UAM (15.7), CARBYN (16.0)
Marsh Hawk	500.0	UAM
Northern Three-Toed Woodpecker	56.9	UAM
Northern Waterthrush	17.3	UAM (17.0, LSU (17.6)
Orange Crown Warbler	9.5	UAM (9.8), WEST & DEWOLFE (8.3)
Olive-Sided Flycatcher	34.1	UAM
Pine Grossbeak	59.7	UAM
Rusty Blackbird	48.9	UAM
Ruby-Crowned Kinglet	7.0	UAM (6.3), WEST & DEWOLFE (6.6), CARBYN (8.0)
American Robin	88.0	UAM, CARBYN (88.0)
Redpoll Sparrow	14.2	UAM - FOR COMMON RPL
Red-Tailed Hawk	1055.0	UAM
Savannah Sparrow	18.0	UAM
Spruce Grouse	561.2	UAM
Sandhill Crane	2481.0	UAM
Song Sparrow	21.0	NICE
Sharp-Tiled Grouse	693.0	UAM
Swainson's Thrush	28.0	UAM (27.4), WEST & DEWOLFE (26.8), CARBYN (31)
Tree Sparrow	17.9	UAM
Upland Sandpiper	151.2	UAM
Varied Thrush	78.5	UAM
Whimbrel	297.5	UAM
White-Crowned Sparrow	24.0	UAM (23.7) WEST & DEWOLFE (25.0)
White-Winged Crossbill	24.4	UAM
Yellow-Rumped Warbler	12.5	UAM (13.0), WEST & DEWOLFE (8.3)
Yellow Warbler	9.7	UAM (10.0) WEST & DEWOLFE (9.4)
Northern Three-Toed Woodpecker	341.0	UAM 12.3), west & dewolfe (13.6),

BORROWER'S CARD

JK 870 .L3 06 no.25
Bird communities of recently
burned and unburned forest

DATE LOANED	BORROW	OFFICE	DATE RETURNED

Form 1279-3 (June 1984)

USDI – BLM

(Continued on reverse)

BLM LIBRARY
SC-324A, BLDG. 50
DENVER FEDERAL CENTER
P. O. BOX 25047
DENVER, CO 80225-0047

DATE DUE

GAYLORD PRINTED IN U.S.A.

Bureau of Land Management

PUBLIC LANDS USA

USE ☆ SHARE ☆ APPRECIATE

BLM Mission Statement

The Bureau of Land Management is responsible for the balanced management of the public lands and resources and their various values so that they are considered in a combination that will best serve the needs of the American people. Management is based upon the principles of multiple-use and sustained yield; a combination of uses that takes into account the long term needs of future generations for renewable and non-renewable resources. These resources include recreation, range, timber, minerals, watershed, fish and wildlife, wilderness, and natural, scientific and cultural values.

BLM-Alaska Mission Statement

In Alaska, the Bureau of Land Management is responsible for carrying out the mandates of the Alaska Native Claims Settlement Act, the Alaska National Interest Lands Conservation Act, and the Alaska Statehood Act along with the Federal Land Policy and Management Act and other federal laws. These duties make cooperative management a vital necessity. BLM-Alaska's success as a public land guardian and resource manager is dependent on its ability to serve the public through mutual understanding. Sustaining a working partnership with the public is a key element of multiple use management, given the special nature of Alaska and its people. To this end, BLM-Alaska:

*exists to serve the public

*safeguards the land and ensures needed resources are available to future generations

*keeps the nations promises of the land to the Natives and the State of Alaska

*serves as an information storehouse for the public